3.11 MIXED OXIDE FUEL FABRICATION SITE (GENERIC)

For the generic MOX fuel fabrication facility, the environmental baseline is representative of an existing reactor fuel fabrication facility currently operating in the contiguous United States. Nuclear fuel fabrication on a commercial scale in the United States is currently limited to five major nuclear fuel fabricators. The five existing reactor fuel fabrication sites that were used as the basis for creating the generic environment are the following:

- ABB–Combustion Engineering, Hematite, MO
- Framatome Commercial Nuclear Fuel Plant, Lynchburg, VA
- General Electric Nuclear Production Facility, Wilmington, NC
- Siemens Nuclear Power Corporation, Richland, WA
- Westinghouse Columbia Fuel Facility, Columbia, SC

The commercial nuclear fuel facilities are primarily engaged in the manufacture of fuel assemblies for commercial nuclear reactors, both BWRs and PWRs. In general, the operations consist of receiving LEU hexafluoride (UF_6); converting the UF_6 to produce UO_2 powder; and processing the UO_2 through pressing and sintering, fuel rod loading and sealing, and fuel assembly fabrication. The fabrication varies in both process and magnitude from site to site.

Currently, there are no commercial U.S. fuel fabrication facilities licensed to process MOX fuel. Processing of MOX fuel in commercial facilities would require licensing by the NRC. The NRC licensing application process includes compliance with site-specific NEPA requirements.

Department of Energy Activities. There are no major DOE activities at these commercial facilities.

Non-Department of Energy Activities. The range of primary missions of the commercial fuel fabrication facilities are as follows: one fabrication facility limits current operation to only loading fuel rods for PWRs; others provide a wide range of fuel fabrication for PWRs only or BWRs only; and one facility fabricates fuel for both BWRs and PWRs.

3.11.1 LAND RESOURCES

The approach to defining the generic MOX fuel fabrication site environmental setting for land resources is not site-specific. Consequently, a range of land use and visual resources conditions has been provided (see Table 3.11.1–1).

Table 3.11.1–1. Land Resources Attributes of the Generic Mixed Oxide Fuel Fabrication Site

Land Use Attributes	
Land Area	30 ha to 695 ha
Land Ownership	Public or Private
Percent of Site Area Developed	2 to 20 percent
Existing Land Use	
Onsite	Industrial; Undeveloped
Offsite	Forest land; Agriculture; Residential; Commercial; and/or Industrial
Land Use Compatibility	Likely
Plans, Policies, and Controls	
Jurisdiction	DOE; other Federal; State; local
Enforcement	Lax to stringent
Conformance	Likely
Visual Resource Attributes	
Landscape Character	
Site	Flat to gently rolling topography
Viewshed	Small to medium size urbanized area; surrounding agriculture; and/ or forest
Visual Resource	
Sensitivity level	Low to medium to high
Distance zones	Foreground, middleground, background, and seldom-seen
BLM VRM class	4 to 5
Degree of contrast	Weak to moderate

Source: BW NRC 1976a; BW NRC 1983b; CE 1989a; GE 1989a; GE 1989b; GE 1989c; GE NRC 1984a; NRC 1981b; NRC 1982a; SPC 1992a; WEC 1975a.

Land Use. The land area requirement for a site would range from 30 ha to 695 ha (74 acres to 1717 acres). Plant facilities would be sited upon only a portion of the total site area, with the developed portion likely to range from 2 to 20 percent. The range of land uses for the undeveloped portion of the site would be grassland, forest, or swampland.

The location of a generic MOX fuel fabrication site would likely range in distance from less than 1 km to 5 km (0.6 mi to 3.1 mi) from the nearest community. Although a site could be located within a city corporate limit, it is more likely to be further from the closest city or metropolitan area, ranging between 6 and 56 km (3.7 and 34.8 mi) distant.

Land uses within the site vicinity would be described as rural, with forest land and agricultural uses predominating. The full range of land uses could include undeveloped uses such as forest and agriculture to developed uses such as residential, commercial, and industrial. The nearest residence would range from 200 to 800 m (656 to 2,625 ft) from the site boundary.

Depending on location, the site could be subject to a variety of land-use plans, policies, and controls at the Federal, State, and local level. The existence and stringency of these plans, policies, and controls could vary by jurisdiction. However, it is likely that site development would be in conformance with land-use plans, policies, and controls, and be compatible with adjacent land use.

Visual Resources. The visual environment of the site would likely be characterized by level to gently rolling topography. The site would be a developed area that contains facilities and activities, surrounded by undeveloped land. The viewshed would likely be rural with a low population density and with forested and agricultural uses predominating. Facilities would likely be visually unobtrusive due to site design, earthwork, and landscaping. The full range of sensitivity levels, and distance zones could occur (see Section 3.1.1 for discussion of visual resource inventory). Public viewpoints could include public access roadways, urbanized areas, and water-based recreational uses. It is likely that the degree of contrast would range from weak to moderate. The site would likely range from a Class 4 to Class 5 BLM VRM designation.

3.11.2 SITE INFRASTRUCTURE

Baseline Characteristics. The baseline characteristics for a generic MOX fuel fabrication site are provided in Table 3.11.2–1. Characteristics of a regional power pool to supply the generic MOX fuel fabrication site are given in Table 3.11.2–2.

Table 3.11.2–1. Generic Mixed Oxide Fuel Fabrication Site Baseline Characteristics

Characteristics	Site Availability
Transportation	
Roads (km)	3 to 9
Railroads (km)	0 to 4.3
Electrical	
Energy consumption (MWh/yr)	49,500 to 72,000
Peak load (MWe)	0.5 to 10
Fuel	
Natural gas (m^3/yr)	0 to 102,800,000
Oil (l/yr)	0 to 9,130,000
Coal (t/yr)	0 to 208,700
Steam (kg/hr)	0 to 11,000

Source: CFFF 1995a:1; GE 1995a:1; SPC 1995a:1.

Table 3.11.2–2. Generic Mixed Oxide Fuel Fabrication Site Sub-Regional Power Pool Electrical Summary

Characteristics	Energy Production
Type Fuel[a]	
Coal	14 to 59%
Nuclear	0 to 39%
Hydro/geothermal	2 to 46%
Oil/gas	<1 to 32%
Other[b]	0 to 30%
Total Annual Production	107,607,000 to 272,155,000 MWh
Total Annual Load	104,621,000 to 293,262,000 MWh
Energy Exported Annually	-45,400,000 to 6,359,000 MWh
Generating Capacity	24,870 to 61,932 MWe
Peak Demand	20,578 to 57,028 MWe
Capacity Margin[c]	4,064 to 13,655 MWe

[a] Percentage does not total 100 percent due to round-off error.
[b] Includes power from both utility and nonutility sources.
[c] Capacity margin is the amount of generating capacity available to provide for scheduled maintenance, emergency outages, system operating requirements, and unforeseen electrical demand.
Source: NERC 1993a.

3.11.3 AIR QUALITY AND NOISE

Meteorology and Climatology. The meteorological and climatological conditions for potential generic MOX fuel fabrication sites in the United States include a wide range of extremes in ambient temperature, windspeed and direction, and precipitation. Therefore, no further description of meteorology and climatology has been provided with respect to a generic site.

Ambient Air Quality. Ambient air quality conditions at representative existing fuel fabrication sites in the United States include a wide range of pollutants and conditions. The existing commercial fuel fabrication sites are all expected to comply with the ambient air quality standards. None of these sites is located in a nonattainment area.

Noise. Specific existing noise sources and characteristics of a generic MOX fuel fabrication site cannot be described. However, it is expected that the area near such a site would be essentially rural in character and would have typically low background sound levels. Typical DNL in the range 35 to 50 dBA (EPA 1974a:B-4) can be expected for such a rural location where noise sources may include wind, insect activity, aircraft, and agricultural activity. Existing industrial noise sources and traffic noise at the site would result in higher background noise levels near the site and along site access routes.

3.11.4 WATER RESOURCES

Surface Water. Major surface water features in the generic MOX fuel fabrication site could range from none to a large navigable river. The average flow rate of these water bodies could range from 0 to 3,360 m^3/s (0 to 118,658 ft^3/s). Other surface water features could include small streams bordering the site with average flows ranging from comparable to the main surface water body's to negligible in comparison.

Stormwater control retention/drainage ponds could be present at the site. These ponds would probably discharge to the nearest surface water body, or to natural drainage channels. Portions of the site could be located within the 100-year floodplain.

Surface Water Quality. In the vicinity of the generic MOX fuel fabrication site, the surface water bodies could range from being classified as fresh water suitable for drinking water, contact recreation, and propagation of fish and aquatic life, to not suitable for drinking, bathing, or commercial shellfishing. The range of concentrations of typical surface water quality parameters that could be encountered at a generic site is the same as was presented in Table 3.10.4–1.

The generic commercial MOX fuel fabrication site would have an NPDES permit(s) that would dictate the acceptable levels of specific parameters in the liquid effluents that would be discharged to a nearby surface water body.

Surface Water Rights and Permits. Surface water rights concerning the water body near the generic MOX fuel fabrication site would involve non-impairment of designated uses.

Groundwater. The near-surface aquifer beneath the generic MOX fuel fabrication site would occur under unconfined conditions and could range in average thickness from 5 to more than 20 m (16.4 to more than 66 ft). Depth to groundwater could range from near the ground surface to more than 200 m (656 ft). The aquifer material could range from sand and gravel to saprolite, or highly weathered bedrock. In general, the generic MOX fuel fabrication site would obtain groundwater from a confined aquifer underlying the near-surface aquifer. The confined aquifer would have an abundant supply of good quality groundwater.

Recharge to the near-surface aquifer would be primarily from rainfall and would occur in areas located up to 10 km (6.25 mi) from the site. Groundwater flow would typically be from these recharge areas towards the major surface water feature.

In areas surrounding the generic MOX fuel fabrication site, groundwater would be used for domestic, agricultural, and industrial purposes. The classification of the aquifer would be a Class II aquifer (that is, currently being used or a potential source of drinking water).

Groundwater Quality. Groundwater quality of the near-surface aquifer in the site area would range from good to fair. The ranges of hydraulic characteristics of the aquifer are presented in Table 3.10.4–2.

Groundwater Availability, Use, and Rights. Groundwater rights concerning the aquifer(s) near the generic MOX fuel fabrication site could range from having potential for local restrictions on pumping to a reasonable use doctrine concerning neighboring landowners water availability.

3.11.5 GEOLOGY AND SOILS

Geology. The physiography of a generic MOX fuel fabrication site could range from a flat, nearly featureless plain to a highly dissected plain of arid to humid environments. Similarly, the area geology could range from alluvium to thick sequences of unconsolidated marine sediments, glaciofluvial material, and crystalline and sedimentary bedrock. These materials could range in age from Cenozoic to Precambrian (recent to over 600 million years).

A generic MOX fuel fabrication site could be located in Seismic Zones 1 to 3, which suggests there could be minor to major levels of damage in the event of an earthquake (Figure 3.2.5–1). [Text deleted.] The geologic terrain for Seismic Zones 1 through 3 of those areas considered for the generic MOX fuel fabrication site could have a history of seismic activity that ranges from low to severe. The nearest capable fault could be within 250 km (155 mi) of the generic MOX fuel fabrication site. The nearest local earthquake with a MMI of V could be within 170 km (106 mi) from a generic MOX fuel fabrication site (Table 3.2.5–1). The nearest epicenter from a damaging earthquake (MMI of VII or greater) could be approximately 170 km (106 mi) from a generic MOX fuel fabrication site.

Although the generic MOX fuel fabrication site is not located within a region of active volcanism, it could be located within approximately 164 km (102 mi) of a volcano.

Soils. The generic MOX fuel fabrication site could be located where the predominant soil types are loamy sands to loamy clays. These soils could range from poorly to excessively drained. The erosion potential could range from minor to severe in those areas with slopes greater than 25 percent and that have been eroded in the past. The soil's shrink-swell potential could range from minimal to severe, which is acceptable for standard construction techniques, depending upon the engineering controls employed. Wind erosion potential could range from minimal to severe.

3.11.6 BIOLOGICAL RESOURCES

The affected environment for the generic MOX fuel fabrication site is based on a review of biological conditions characteristic of several commercial reactor fuel fabrication facilities currently operating in the United States. Biological resources at a given site could vary from those typically associated with the principal vegetation type of the area due to a variety of factors, including previous disturbance by man. The principal vegetation types found within these representative environments include deciduous forest, southeastern evergreen forest, and grassland. With the exception of southeast evergreen forest, biological resources found within these vegetation types are discussed in Section 3.10.6.

Southeast Evergreen Forest. Southeast evergreen forest occurs along the Atlantic coastal plain from the mid-Atlantic States to Florida and along the northern Gulf Coast. The climate varies from distinct seasonal changes in the mid-Atlantic region to only minor seasonal variation in Florida and along the Gulf Coast. Pines, such as pitch, longleaf, and slash, are the dominant tree species within this vegetation type. Pine forests owe their origin and maintenance to their resistance to fire, which inhibits the growth of deciduous species. In the absence of fire, this forest type would be replaced by oak-hickory dominated forest. Animals associated with the southeast evergreen forest include the whitetail deer, opossum, gray fox, northern bobwhite, wild turkey, eastern bluebird, morning dove, eastern diamondback rattlesnake, American alligator and pine woods treefrog. Streams and rivers within this vegetation type are generally slow moving and are often bordered by forested swamps and bottomland hardwood forests.

3.11.7 CULTURAL AND PALEONTOLOGICAL RESOURCES

Prehistoric Resources. Prehistoric resources may be affected by the construction and operation of the generic MOX fuel fabrication facility. These resources may include objects, sites, or features such as remains of storage pits, or hearths. Archaeological sites may include hunting and butchering sites and campsites. Sites may yield artifacts such as stone tools and associated manufacturing debris, and ceramic potsherds.

Historic Resources. Historic resources that could be affected by construction and operation may include subsurface remains of human occupation such as structural foundations of buildings, important paths or roads, and cemeteries. Some standing buildings such as commercial structures and residences also may be considered historic resources.

Native American Resources. Native American resources could be affected by construction and operation of this facility. Resources may include sites, areas, and materials important to Native Americans for religious or heritage reasons. Sacred sites may include cemeteries, plant communities, mountains, paths, or geographical spaces that are socially identified and circumscribed. Some Native American groups could be affected and would need to be consulted if a specific site is chosen.

Paleontological Resources. Paleontological resources could be affected. These resources may include fossil remains of extinct plants or animals, some rare. They can include poorly known fossil forms, well-preserved terrestrial vertebrates, unusual depositional contexts, assemblages that contain a variety of fossil forms, or deposits recovered from poorly studied regions or in unusual concentrations.

3.11.8 SOCIOECONOMICS

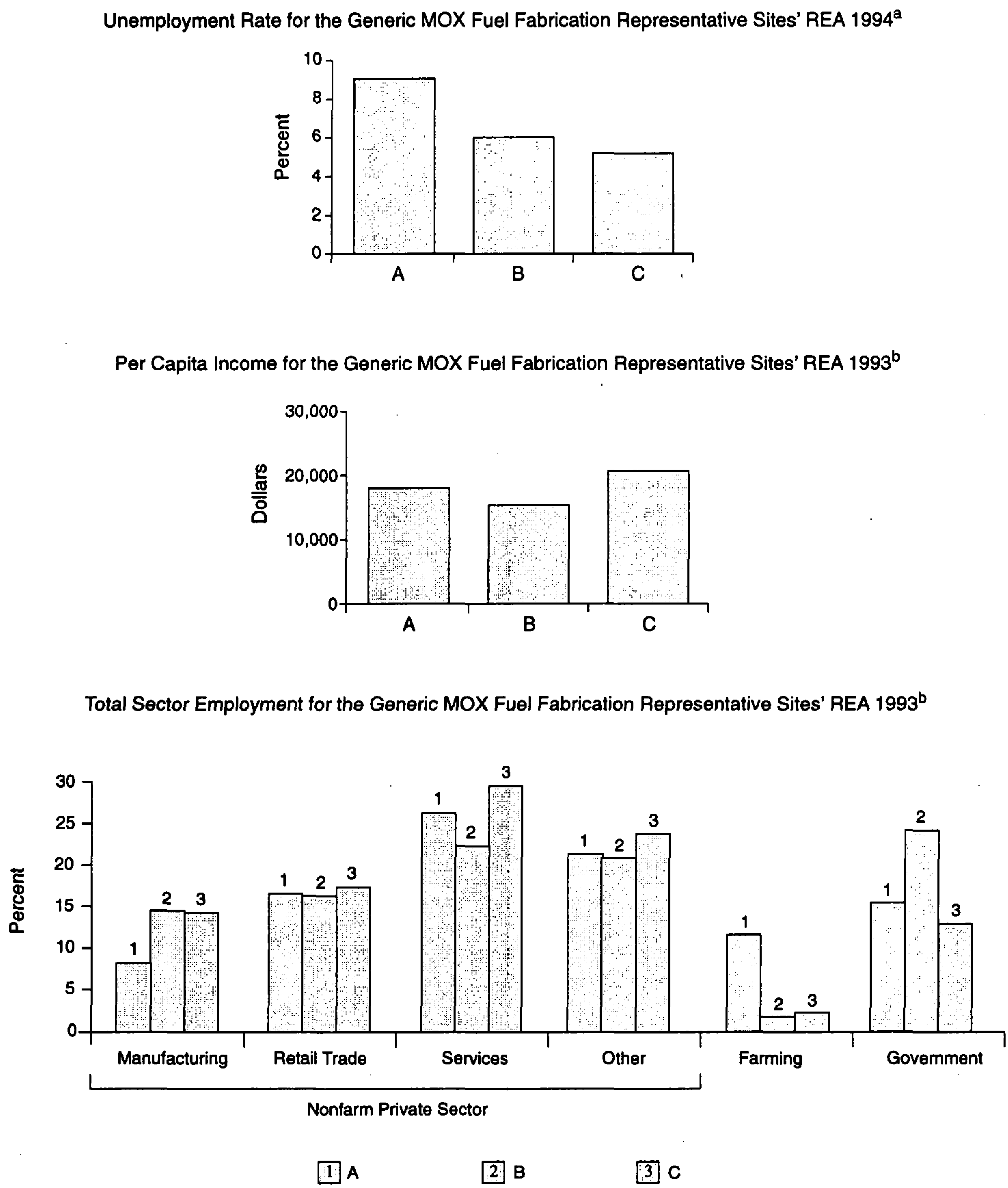
The generic MOX fuel fabrication site could potentially affect the socioeconomic environment of a given REA or ROI. The characteristics of the REA, ROI, and community are dependent upon geographic location. For employment and income, the economic area would be based upon industry interaction and linkages in the region. The anticipated residential distribution of project-related employees and their families would determine the ROI. This ROI would contain all principal jurisdictions and school districts likely to be affected by the proposed activity.

Because specific sites have not been proposed for the generic MOX fuel fabrication facility, representative sites have been used to describe the affected environment. Five existing facilities encompassing three location types were used as representative sites to develop a range of conditions for discussion in this section. Two of the sites, A and B, are located in medium communities located in urban areas. The third site, C, is a small community tied to a large metropolitan area. Medium-size communities and the vulnerability or susceptibility of a local community to changes in the economic base are characterized in Section 3.10.8.

Small communities tied to large metropolitan areas would be characterized by a rural ROI within a large metropolitan REA. The ROI would have attributes similar to rural areas and small rural communities. The population would normally be less than 50,000. There would be small business centers with a small work force and little local diversification of industries and employment. However, the large metropolitan area nearby should provide employment for a significant portion of the rural community's population. The resulting increase in tax base and diversification of employment would strengthen the community's economic base and allow for a higher level of community services than found in a more isolated rural area. Infrastructure and transportation networks would normally be more developed in the rural community linked to a large metropolitan area than in a more isolated community. This would be due, in part, to the requirement for good commuting routes to the large metropolitan area. The large metropolitan area to which the rural community is linked would have a population of at least 1 million. These communities would usually be independent centers of large-scale financial, wholesaling, and service activity. These areas would typically have high population densities and numerous employment centers. Economically supportive relationships between industries would be developed, and a large pool of labor would exist. Large and diverse metropolitan areas would provide a wide range of goods and services to local residents.

Socioeconomic characteristics described for the generic MOX fuel fabrication site include employment and local economy, population and housing, and local transportation. The communities of three typical sites were assessed. Site A, which had a 1992 population of 34,201 and a total urban population of more than 100,000, represents the smaller medium-size community being assessed; Site B, with a 1992 population of 98,832, represents the larger medium-size community being assessed. Site C was a small community whose population was incorporated into the population of the surrounding county. Site C was located approximately 16 km (10 mi) from a small community of 4,096 persons (1992 population) and about 64 km (40 mi) from a large metropolitan area of approximately 1.5 million persons. Statistics for employment and local economy were based on the REA for each site. Statistics for the remaining socioeconomic characteristics were based on the sites' ROIs.

Regional Economy Characteristics. Selected employment and regional economy statistics for each typical site's REA are discussed in this section and displayed in Figure 3.11.8–1. Between 1980 and 1990, the civilian labor force in the REA encompassing Site A increased 9.9 percent to the 1990 level of 254,800, and in Site B increased 19 percent to the 1990 level of 399,100. Site C had a 12.6 percent increase (the 1990 civilian labor force was 1,476,800). The 1994 unemployment for the REA encompassing Site A was 9.1 percent while Site B had unemployment of 6 percent. The unemployment for Site C was 5.3 percent. The 1993 per capita income was $18,501 and $16,832 for Sites A and B, respectively. Site C had a 1993 per capita income of $20,554.



[a] DOL 1995a.
[b] DOC 1995a.

Figure 3.11.8–1. Employment and Local Economy for the Generic Mixed Oxide Fuel Fabrication Representative Sites' Regional Economic Area.

Figure 3.11.8–1 displays the division of employment involving farming, nonfarm private sector, and government employment around each representative site. The portion of total REA employment involving farming was 12 percent at Site A and 2 percent at Site B. Government activities accounted for 15 and 24 percent of the total regional employment at sites for A and B, respectively. Employment involving manufacturing was 8 percent of the total employment in the region surrounding Site A and 14 percent in the region around Site B. Retail trade activities represented approximately 16 percent of the nonfarm private sector employment for Site A and Site B. Service activities represented a 26-percent share of this employment for Site A, and a 22 percent share at Site B.

For Site C, the portion of total employment involving farming and government activities was 2 percent and 13 percent, respectively. The nonfarm private sector activities of manufacturing and retail trade represented 14 percent and 17 percent, respectively, of the total regional employment. Employment in the service sector was 29 percent.

Population and Housing. Population and housing trends in the ROIs of the three typical communities are presented in Figure 3.11.8–2. The ROI population increases for Sites A and B between 1980 and 1994 were 19.8 percent (average annual increase of 1.3 percent) and 18.1 percent (average annual increase of 1.3 percent), respectively. The number of housing units, between 1980 and 1990, in the ROI increased 5.4 percent for Site A and 21.6 percent for Site B. The 1990 ROI homeowner vacancy rates were 1.3 percent for Site A and 1.9 percent for Site B, while the renter vacancy rates were 5.6 percent and 8.9 percent for Sites A and B, respectively.

The ROI surrounding Site C experienced a 5.2-percent (average annual increase of 0.4 percent) increase in population, between 1980 and 1994, and an 11.9-percent increase in the number of housing units between 1980 and 1990. The 1990 homeowner and renter vacancy rates were 1.8 and 9.1 percent, respectively.

Community Services and Local Transportation. These characteristics are dependent upon a geographic location. The ROI would determine all principal jurisdictions and school districts likely to be affected by the proposed activity. Local transportation would be the existing principal road, air, and rail networks required to support the project activities.

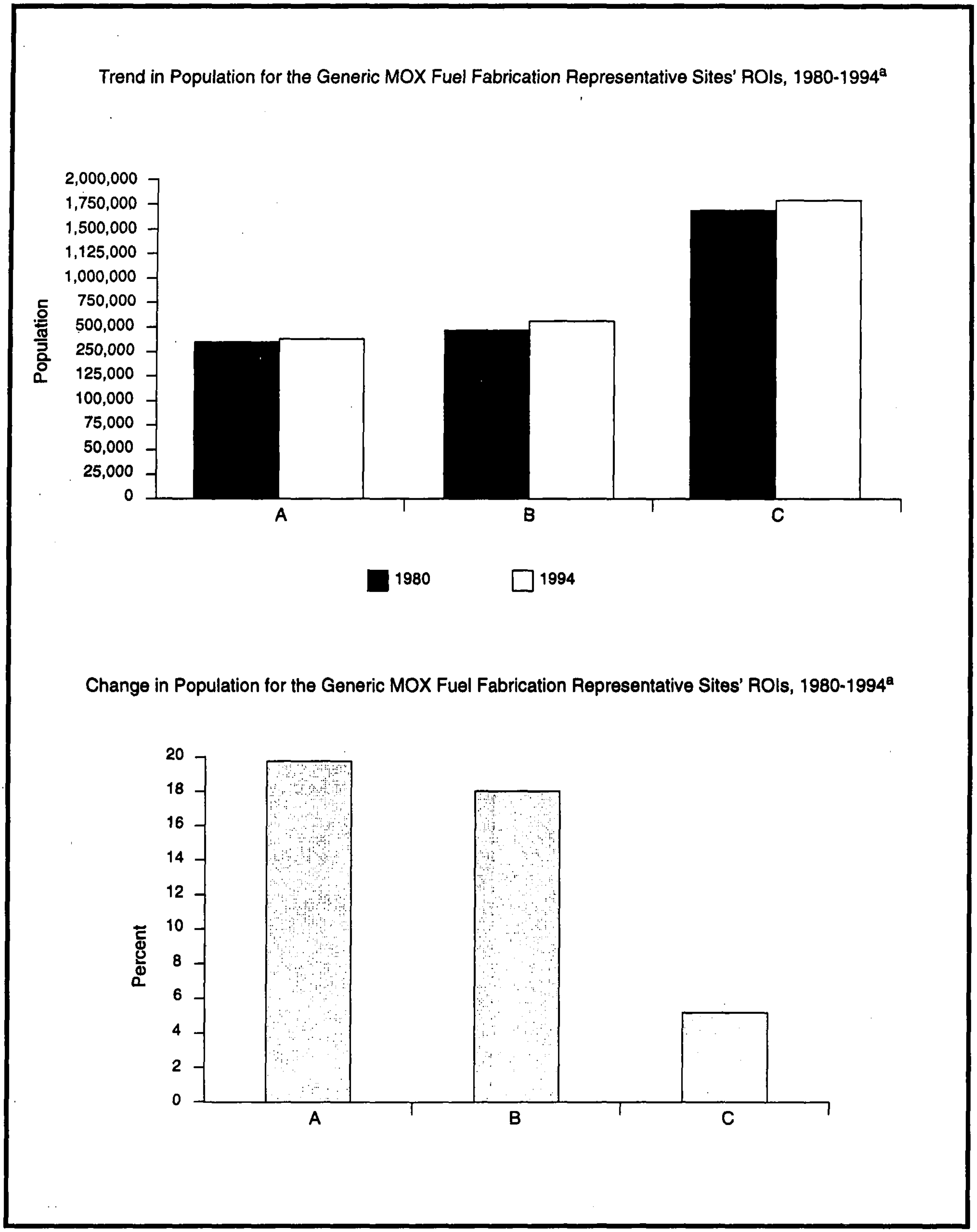
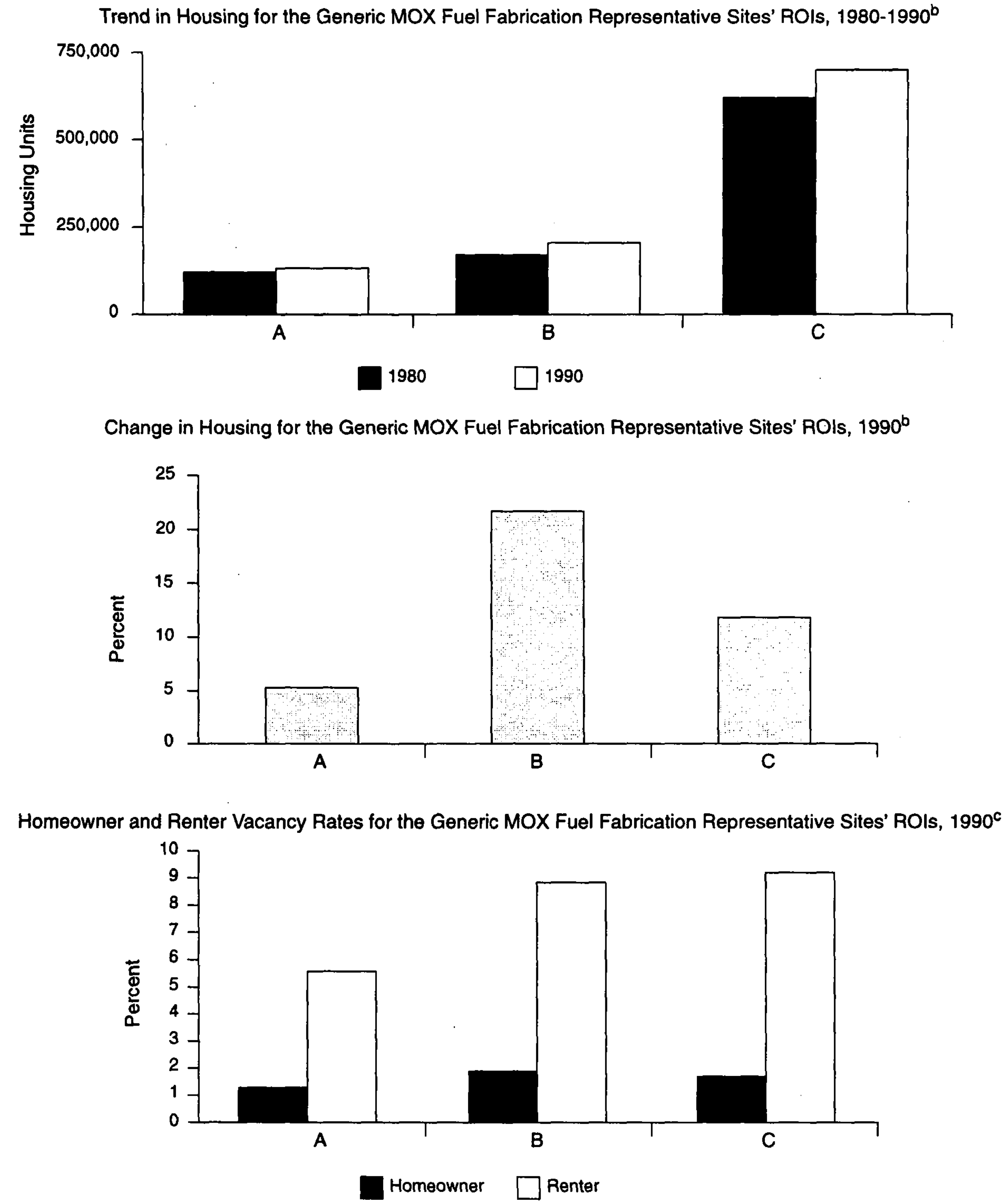


Figure 3.11.8–2. Population and Housing for the Generic Mixed Oxide Fuel Fabrication Representative Sites' Region of Influence.



[a] Census 1983b; Census 1983k; Census 1983m; Census 1995a.
[b] Census 1982c; Census 1982f; Census 1982r; Census 1991b; Census 1991d; Census 1991f.
[c] Census 1991b; Census 1991d; Census 1991f.

Figure 3.11.8–2. Population and Housing for the Generic Mixed Oxide Fuel Fabrication Representative Sites' Region of Influence—Continued.

3.11.9 PUBLIC AND OCCUPATIONAL HEALTH AND SAFETY

Radiation Environment. Major sources and levels of representative background radiation exposure to individuals in the vicinity of a generic MOX fuel fabrication site are shown in Table 3.11.9–1. Annual background radiation doses to individuals are expected to remain constant over time. The total dose to the population changes as the population size changes. Background radiation doses are unrelated to normal facility operation.

Table 3.11.9–1. Sources of Radiation Exposure to Individuals in the Vicinity, Unrelated to Operation at the Generic Mixed Oxide Fuel Fabrication Site

Source	Effective Dose Equivalent (mrem/yr)
Natural Background Radiation	
Cosmic and cosmogenic radiation[a,b]	27 to 28
External terrestrial radiation[a]	15 to 44
Internal terrestrial radiation[b]	39
Radon in homes (inhaled)[b]	200
Other Background Radiation[b]	
Diagnostic x rays and nuclear medicine	53
Weapons test fallout	<1
Air travel	1
Consumer and industrial products	10
Total	346 to 376

[a] Based on information on cosmic and terrestrial radiation given in EPA 1981b.
[b] NCRP 1987a.
Note: Value for radon is an average for the United States.

Releases of radionuclides to the environment from normal facility operations provide another source of radiation exposure to individuals in the vicinity of a given site. For a range of existing conditions, types and quantities of radionuclides released from operations at a generic MOX fuel fabrication site is based on 1994 radiological effluent release reports for existing representative commercial fuel fabrication sites involved in the processing and fabrication of uranium ore into reactor fuel. The doses to the public resulting from these releases are presented in Table 3.11.9–2. These doses fall within radiological limits (40 CFR 61, 40 CFR 141, and 40 CFR 190) and are small in comparison to background radiation. The releases listed in the 1994 reports were used in the development of the reference environment's (No Action) radiological releases and resulting impacts at the generic MOX fuel fabrication sites in the year 2005 (Section 4.3.5.1.9).

Based on a risk estimator of 500 cancer deaths per 1 million person-rem to the public (Section M.2.1.2), the fatal cancer risk to the maximally exposed member of the public due to radiological releases from operations at the representative fuel fabrication sites in 1994 is estimated to range from 2.5×10^{-7} to 5.5×10^{-7}. That is, the estimated probability of this person dying of cancer at some point in the future from radiation exposure associated with 1 year of operations at the representative fuel fabrication site ranges from less than 3 in 10 million to less than 6 in 10 million. (Note that it takes several to many years from the time of exposure to radiation for a cancer to manifest itself.)

Based on the same risk estimator, a range of 1.8×10^{-4} to 5.8×10^{-3} excess fatal cancers is projected in populations living within 80 km (50 mi) of the representative fuel fabrication sites from normal operations in 1994. To place these numbers into perspective, they can be compared with the numbers of fatal cancers expected in these

Table 3.11.9–2. Radiation Doses to the Public From Normal Operation at the Generic Mixed Oxide Fuel Fabrication Site in 1994 (Committed Effective Dose Equivalent)

Members of the General Public	Atmospheric Releases		Liquid Releases		Total	
	Standard[a]	**Actual**	**Standard[a]**	**Actual**	**Standard[a]**	**Actual**
Maximally exposed individual (mrem)	10	0.058 to 0.50	4	0.002 to 1.0	25	0.50 to 1.1
Population within 80 km[b] (person-rem)	None	0.30 to 11.1	None	0.050 to 0.48	None	0.35 to 11.6
Average individual within 80 km[c] (mrem)	None	$5.7x10^{-4}$ to 0.013	None	$9.5x10^{-5}$ to $5.7x10^{-4}$	None	$6.7x10^{-4}$ to 0.014

[a] The standards for individuals are given in 40 CFR 61, 40 CFR 141, and 40 CFR 190. As discussed in these regulations, the 10 mrem per year limit from airborne emissions is required by the CAA, the 4 mrem per year is required by the SDWA, and the total dose of 25 mrem per year is the limit from all pathways combined.

[b] In 1994, this population ranged from 525,000 to 848,000.

[c] Obtained by dividing the population dose by the number of people living within 80 km of the site.

Source: BW 1995b:1; WEC 1975a; WEC 1995a:1.

populations from all causes. The 1990 mortality rate associated with cancer for the entire U.S. population was approximately 0.2 percent per year (Almanac 1993a:839). Based on this mortality rate, the number of fatal cancers expected to occur during 1994 from all causes ranged from 1,050 to 1,700 in the population living within 80 km (50 mi) of a fuel fabrication site. These numbers of expected fatal cancers are much higher than the estimated range of $1.8x10^{-4}$ to $5.8x10^{-3}$ fatal cancers that could result from operations at commercial fuel fabrication sites in 1994.

Site workers receive the same dose as the general public from background radiation but also receive an additional dose from working in the site facilities. Table 3.11.9–3 presents the range of the average worker, maximally exposed worker, and total cumulative worker dose from operations at the representative fuel fabrication sites in 1993. These doses fall within radiological regulatory limits (10 CFR 20). Based on a risk estimator of 400 fatal cancers per 1 million person-rem among workers (Section M.2.1.2), the number of excess fatal cancers to workers from site operations in 1993 is estimated to range from 0.0028 to 0.039.

Table 3.11.9–3. Radiation Doses to Workers From Normal Operation at the Generic Mixed Oxide Fuel Fabrication Site in 1993 (Committed Effective Dose Equivalent)

Occupational Personnel	Onsite Releases and Direct Radiation	
	Standard[a]	**Actual**
Average worker (mrem)	ALARA	33 to 159
Maximally exposed worker (mrem)	5,000	<3,000
Total workers (person-rem)	ALARA	7.0 to 98

[a] NRC's goal is to maintain radiological exposure as low as reasonably achievable.

Source: 10 CFR 20; NRC 1995b.

A more detailed presentation of the radiation environment, including background exposures and radiological releases and doses, is presented in the 1994 effluent release reports and environmental reports. The concentrations of radioactivity in various environmental media (including air, water, and soil) in the regions of the sites (onsite and offsite) are also presented in those reports.

Chemical Environment. The background chemical environment important to human health consists of the atmosphere, which may contain hazardous chemicals that can be inhaled; drinking water, which may contain hazardous chemicals that can be ingested; and other environmental media with which people may come in contact (for example, surface waters during swimming and soil through direct contact or via the food pathway). The baseline data for assessing potential health impacts from the chemical environment are those presented in Section 3.11.3.

Effective administrative and design controls that decrease hazardous chemical releases to the environment and help achieve compliance with permit requirements (that is, air emissions and NPDES permit requirements) contribute toward minimizing potential health impacts to the public. The effectiveness of these controls is verified through the use of monitoring information and inspection of mitigation measures. Health impacts to the public may occur during normal operations at the fuel fabrication site via inhalation of air containing hazardous chemicals released to the atmosphere by site operations. Risks to public health from other possible pathways, such as ingestion of contaminated drinking water or direct exposure, are low relative to the inhalation pathway.

A discussion of ambient air quality is given in Section 3.11.3. As stated in that section, air quality is expected to be in compliance with applicable standards. Information about estimating health impacts from hazardous chemicals is presented in Section M.3.

Exposure pathways for workers at the fuel fabrication site during normal operations may include inhaling the workplace atmosphere and direct contact with hazardous materials associated with work assignments. The potential for health impacts varies from facility to facility and from worker to worker, and available information is not sufficient to allow a meaningful estimation and summation of these impacts. However, workers are protected from hazards specific to the workplace through appropriate training, protective equipment, monitoring, and management controls. Site workers are also protected by adherence to OSHA and EPA standards that limit workplace atmospheric and drinking water concentrations of potentially hazardous chemicals. Appropriate monitoring that reflects the frequency and amounts of chemicals utilized in the operational processes ensures that these standards are not exceeded. Therefore, worker health conditions are expected to be substantially better than required by the standards.

Health Effects Studies. Specific locations for the MOX fuel fabrication facilities must be designated before any reviews of epidemiologic studies in the areas can be conducted.

Accident History. Domestic MOX fuel fabrication facilities do not presently exist. Consequently, there is no accident history available.

Emergency Preparedness. The generic MOX fuel fabrication site would develop an emergency management program which would be activated in the event of an accident. The program would be compatible with all other Federal, State, and local plans and is thoroughly coordinated with all interested groups. [Text deleted.]

3.11.10 WASTE MANAGEMENT

This section describes the range of waste management activities and the regulatory framework that exist at a generic fuel fabrication site in the United States. These commercial facilities would need to be licensed by NRC to handle Pu. To meet the requirements of their NRC license, the generic fuel fabrication site complies with Federal and State regulations of water, air, and land disposal in addition to facility permits. Agencies responsible for enforcement and inspection at a commercial nuclear fuel fabrication facility include the NRC, EPA, and the State's appropriate regulatory agencies. State agencies govern effluent discharge; nonhazardous waste disposal; hazardous waste treatment, storage, and disposal; underground storage tanks; incineration; and transport of hazardous waste.

A generic fuel fabrication site receives low-enriched UF_6 and/or UO_2 (made from natural or depleted uranium) as powder. The UO_2 powder is pressed into pellets, which are sintered, ground to final size, and loaded into fuel rods that are then fabricated into reactor fuel bundles. Wastes produced at this site are categorized as low-level, mixed low-level, hazardous, and nonhazardous. Activities at a generic fuel fabrication site that generate waste include uranium blending; pelleting; sintering; grinding; coating; fuel rod loading and inspection; scrap recovery; incineration of low-level radioactive, mixed low-level, hazardous, and nonhazardous wastes; recovery of zirconium and copper; waste compaction; and waste processing and research related to the recovery of uranium. Incoming materials to the site includes zircalloy tubing, UO_2, nitric acid, water, and natural gas. Exit streams from the site typically include product fuel elements and assemblies; recovered metals; and gaseous, liquid, and solid waste.

The low-level, mixed, hazardous, and nonhazardous wastes are treated to reduce either volume or toxicity for subsequent recycle, storage, or disposal. The quantity of waste and the characteristics of the waste would depend on the fabrication process and the method of treatment used. The following discussions describe the waste management practices that are used at a generic fuel fabrication site.

Spent Nuclear Fuel. The site does not generate or manage spent nuclear fuel.

High-Level Waste. The site does not generate or manage HLW.

Transuranic Waste. The site does not generate or manage TRU waste.

Low-Level Waste. The site produces both liquid and solid LLW; however, liquid LLW is processed for uranium scrap recovery and dried to solids before disposal. Liquid LLW is generated in uranium recovery and gaseous emissions cleanup operations. Many of the manufacturing operations are dry chemical reactions, thus minimizing the generation of liquid LLW. Manufacturing process liquid wastes include acid dissolution, washwater from the laundry and personnel stations, analytical laboratory liquids, and scrubber water from the acid treatment and incineration operations.

The liquid LLW generated can be treated using evaporation, filtration, centrifugation, or ion exchange in a liquid radioactive waste treatment facility. After the complete treatment process, final dried solids are produced that can either be incinerated for further uranium recovery or packaged for offsite disposal at a licensed LLW disposal facility. Liquid effluents from the process can be transferred to a retention tank system and ultimately released to a sanitary sewer or into the local river in accordance with the generic fuel fabrication site's NPDES permit.

Solid waste that is categorized as LLW results from uranium recovery, liquid waste management, and incineration; this waste includes paper, small pieces of equipment, sludge, and miscellaneous trash. Another form of solid LLW results from gaseous waste streams with measurable amounts of radioactive materials that are passed through HEPA filters. These filters are disposed of as LLW. The solid waste produced can be incinerated, and the remaining packaged for offsite disposal. A supercompactor can exist onsite that compacts

208-l (55-gal) drums containing LLW. At a generic fuel fabrication site, the total solid LLW volume is expected to be approximately 41 m^3/yr (54 yd^3/yr).

Mixed Low-Level Waste. The generic fuel fabrication site could processes uranium-containing material using distillation. The sludge bottoms from this process are categorized as mixed LLW. The mixed waste is packaged and stored onsite at a dedicated facility until disposal becomes feasible. The volume of mixed waste generated annually at a generic fuel fabrication site is estimated to be 2 m^3/yr (2.6 yd^3/yr).

Hazardous Waste. Liquid hazardous wastes generated at a generic fuel fabrication site results from acid pickling, metals cleaning, and emissions control operations. Solid hazardous wastes are generated through the liquid hazardous waste treatment operations. The primary treatment methods that are used for liquid hazardous wastes are advanced wastewater treatment, lagoons, precipitation, and retention tanks pending discharge to the local river or sewer system in accordance with the site's NPDES permit. Sludges from these processes are recycled or packaged and shipped offsite for treatment and disposal.

Nonhazardous Waste. Liquid sanitary waste is processed at a generic fuel fabrication site. The primary treatment methods for this waste include sanitary treatment, aeration, and chlorination. As with the other treatment processes for liquid waste, the effluent is ultimately discharged into the local river or sewer system in accordance with the site's NPDES permit. Solid nonhazardous waste at the generic fuel fabrication site includes miscellaneous trash and paper, classified paper, and scrap zirconium and copper. Miscellaneous trash is sorted and packaged for onsite or offsite disposal.